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CORD: A Software Package for Creating Circular ORientation Diagrams

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September 1989

Canadian Technical Report of Fisheries and Aquatic Sciences No. 1706

Fisheries and Oceans Pêches et Océans

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Canadian Technical Report of Fisheries and Aquatic Sciences

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90-01929/

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Cat. No. 97-6/1706E ISSN 0706-6457

Correct citation for this publication:

Nesbitt, D., and J. Schnute. 1989. CORD: A Software Package for Creating Circular ORientation Diagrams. Can. Tech. Rep. Fish. Aquat. Sci. 1706: 19 p.

Table of Contents

List of Tables iv

List of Figures iv

ABSTRACT v

1. INTRODUCTION 1
1.1. An overview of circular orientation diagrams 1
1.2. Installing CORD 3
1.3. An overview of this manual 4

2. CORD: AN EXAMPLE 4
2.1. Working with the CORD demo plot 4
2.2. Working with data from pre-defined files 6

3. CREATING DATA FILES FOR USE WITH CORD 7
3.1. CORD file types 7
3.2. Specifications of type 1 data files 7
3.3. Specifications of type 2 data files 8
3.4. Specifications of CORD case select files 9

4. USING CORD 10
4.1. CORD menu operation 10
4.2. The CORD main menu 10
4.3. Selecting the current image 10
4.4. Viewing CORD plots 10
4.5. The file menu 11
4.5.1. Loading type 1 data files (.DT1) 12
4.5.2. Loading type 2 data files (.DT2) 12
4.5.3. Loading case select files (.CAS) 12
4.5.4. Listing available CORD files 12
4.6. Changing the maximum radius length 12
4.7. Changing the radius of the inner circle 13
4.8. Turning arrow heads on/off 13
4.9. Turning the diagram border on/off 13
4.10. Turning the diagram compass markings on/off 13
4.11. Screen and printer aspect ratios 13
4.11.1. Setting the screen aspect ratio 14
4.11.2. Setting the printer aspect ratio 14
4.12. Printing CORD plots 15
4.12.1. Selecting a printer mode 15
4.12.2. Selecting a printer magnification factor 16
4.13. Exiting CORD 16

REFERENCES 17

APPENDIX A - OBTAINING THE CORD SOFTWARE 17

List of Tables

Table 1.1 - Summary data from a series of orientation experiments . . . 1
Table 1.2 - Summary data from a series of orientation experiments . . 2
Table 4.1 - Printer modes available in CORD 16

List of Figures

Figure 1.1 - CORD diagram corresponding to the data in Table 1.1 . . . 2
Figure 1.2 - CORD diagram corresponding to the data in Table 1.2 . . . 3
Figure 3.1 - Example of a type 1 data file with extension ".DT1" . . . 8
Figure 3.2 - Example of a type 2 data file with extension ".DT2" . . . 9
Figure 3.3 - Example of a case select file with extension ".CAS" . . . 9
Figure 4.1 - The CORD main menu 11

ABSTRACT

Nesbitt, D., and J. Schnute. 1989. CORD: A Software Package for Creating Circular ORientation Diagrams. Can. Tech. Rep. Fish. Aquat. Sci. 1706: 19 p.

This report documents a microcomputer software package that produces circular orientation diagrams for a series of animal orientation experiments. The outcome of each experiment is represented by a vector with polar coordinates (r,θ), where θ represents the direction in which animals tend to orient and r measures the strength of that tendency. The software (CORD, for Circular ORientation Diagram) allows for the possibility that animals may orient bimodally, with a second direction opposite to the first. CORD reads data from an ordinary text file and produces diagrams for arbitrary subsets of the data. Thus, the experimenter can easily represent any group of experiments in a single diagram. CORD produces output both on the screen and the printer, with support provided for common dot matrix and laser printers.

RÉSUMÉ

Nesbitt, D., and J. Schnute. 1989. CORD: A Software Package for Creating Circular ORientation Diagrams. Can. Tech. Rep. Fish. Aquat. Sci. 1706: 19 p.

Le rapport renseigne sur un progiciel pour micro-ordinateur qui produit des diagrammes d'orientation circulaires pour une série d'expériences sur l'orientation des animaux. Le résultat de chaque expérience est représenté par un vecteur en coordonnées polaires (r,θ), θ représentant la direction sur laquelle les animaux tendent à s'orienter et r mesurant la force de cette tendance. Le progiciel CORD (sigle de l'expression anglaise Circular ORientation Diagram) tient compte de la possibilité que les animaux adoptent une orientation bimodale, et que la deuxième direction soit à l'opposé de la première. Le CORD saisit les données à partir d'un fichier-texte ordinaire et produit des diagrammes pour des sous-ensembles arbitraires de données. L'expérimentateur peut aussi représenter facilement tout groupe d'expériences au moyen d'un seul diagramme. Le progiciel peut afficher les diagrammes à l'écran ou les imprimer, sur imprimante par points ou sur imprimante laser.

1. INTRODUCTION

1.1. An overview of circular orientation diagrams

Biologists studying animal behaviour have found circular vector diagrams effective for comparing the results of orientation experiments. A potential disadvantage of these diagrams is the painstaking graphical work involved in producing them, work that must often be repeated when comparing various subsets of the experimental data. This Circular ORientation Diagram package (CORD) relieves the biologist of much of this work by producing such diagrams easily from selected subsets of the available experimental data.

For illustration, consider the data listed in Table 1.1. Each row in the table summarizes an experiment in which animals tended to orient in a direction corresponding to the angle θ. The quantity r measures the strength of this tendency. Thus, case 2 corresponds to the experiment in which animals oriented most strongly.

Table 1.1 - Summary data from a series of orientation experiments. Each of the five experiments is characterized by a vector with polar coordinates (r,θ).

case	r	θ
1	1.1	340
2	2.5	320
3	1.3	70
4	1.5	200
5	0.9	115

The data from Table 1.1 are represented graphically in Figure 1.1. Each experiment is depicted by a vector with radius r and angle θ, measured in degrees clockwise from north. Readers may recognize Figure 1.1 as a diagram familiar from animal behaviour literature. CORD uses the computer to produce such figures easily from the data.

Next consider the data in Table 1.2. These correspond to a recent statistical theory of Schnute and Groot (1989) for describing bimodal animal orientation, where animals move in either the primary direction or its opposite. Again, the angle θ represents the direction of principal orientation. The quantity r indicates the concentration of animals oriented in the directions θ or θ+180°. The value λ ($0 \leq \lambda \leq 1$) indicates the propensity of animals to orient in the direction θ, and $1-\lambda$ represents the propensity in the opposite direction θ+180°. Within CORD, we restrict λ to lie in the interval [0.5,1.0], so that θ corresponds to the principal direction. Thus, if CORD encounters a value of λ between 0 and 0.5, it replaces λ and θ with $1-\lambda$ and θ+180°, respectively.

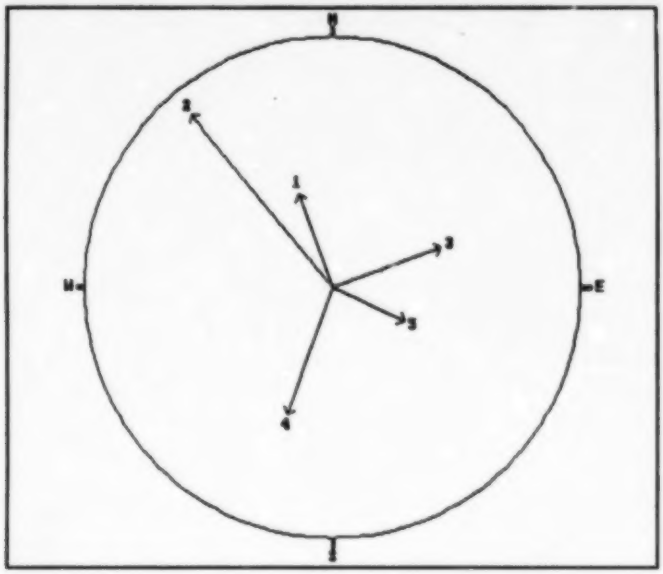

Figure 1.1 - CORD diagram corresponding to the data in Table 1.1.

Figure 1.2 is a diagram derived from the data in Table 1.2. The vectors here terminate as solid lines and originate as dashed lines to indicate the proportions (λ and $1-\lambda$) of animals oriented in the directions θ and $\theta+180°$. Thus, the lengths of solid and dashed portions are proportional to $r*\lambda$ and $r*(1-\lambda)$, respectively. For added clarity, these are separated with marks perpendicular to the vectors. In addition, an inner circle serves to separate the vector clusters near the origin.

Table 1.2 - Summary data from a series of orientation experiments. Each of the eight experiments is characterized by a vector with polar coordinates (r,θ) and by a scalar λ with $0.5 \leq \lambda \leq 1.0$.

case	r	θ	λ
1	16.1	340	0.55
2	22.2	110	0.77
3	16.9	70	0.60
4	5.7	150	0.80
5	20.3	235	0.65
6	22.8	315	0.67
7	14.7	190	0.84
8	9.8	78	0.93

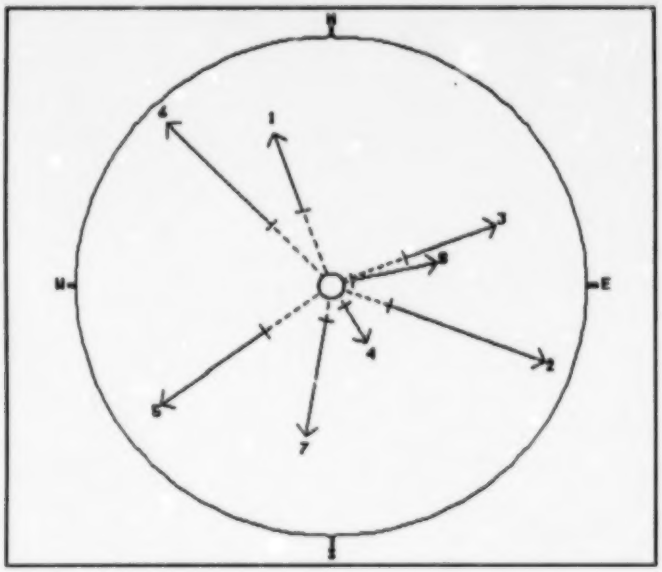

Figure 1.2 - CORD diagram corresponding to the data in Table 1.2.

CORD can produce these diagrams with corrected aspect ratio (i.e., squares appear square and circles appear round) on both the screen and printer. CORD supports most common graphics adapters (CGA, EGA, VGA and Hercules) and printers compatible with the Epson FX-80 and the Hewlett Packard LaserJet Series II. Graphics printing software (Kuhn et al., 1988) is used to produce hardcopy output. The CORD package was written entirely in Turbo Pascal® v5.0. To obtain an image of CORD, refer to the instructions in Appendix A.

1.2. Installing CORD

The following files should be present on the distribution disk:

- READ.ME (Post-release notes)
- CORD.EXE (The CORD program)
- CORD.PAS (CORD source code)
- PRT.TPU (Graphics printing unit from Kuhn et al.(1988))
- DEMO1.DT1, DEMO2.DT2 and CASE.CAS (Files used in demos)
- CGA.BGI, EGAVGA.BGI and HERC.BGI (Borland's graphics drivers)[1]

[1] These .BGI files are distributed with this package under the provision of the Borland International, Inc., Turbo Pascal v5.0® license agreement which states: "In addition, to the extent that the programs you write and compile using the Turbo Pascal language compiler make use of these support files, you may distribute these support files in combination with such programs, provided that you do not use, give away, or sell the support files separately, and all copies of your programs bear a copyright notice."

If you have no hard disk, make a copy of the distribution disk and work from this copy. If you do have a hard disk, then begin by creating a sub-directory for your CORD work and copying all distributed files to it. Only the .BGI file which corresponds to your graphics card need be left in this directory. The remaining .BGI files may be deleted. The correspondence of .BGI files to graphics cards is as follows:

```
CGA.BGI     - CGA card
EGAVGA.BGI  - EGA and VGA cards
HERC.BGI    - Hercules monochrome graphics card
```

Please read the text in the READ.ME file (using the DOS "TYPE" or "PRINT" commands), which may contain information that supersedes this manual.

1.3. An overview of this manual

This manual includes four main sections and one appendix. The first section (above) gives an overview of circular orientation diagrams and the CORD software. Section 2 provides an example of CORD usage. In particular, Section 2.1 leads the user through many CORD features in conjunction with a demo plot. Section 2.2 demonstrates the use of CORD with pre-defined data files.

The two remaining sections provide a detailed reference for all aspects of CORD. Section 3 focuses on the specifications of various CORD files. Section 4 discusses each of the CORD menu options in detail.

2. CORD: AN EXAMPLE

This section provides an interactive example for using the CORD package. We suggest following the text step-by-step on the computer. It illustrates all features of CORD, and prepares the user to create original diagrams.

2.1. Working with the CORD demo plot

Change to the directory (or use the copied floppy disk) that contains the CORD program and the sample data files (CORD.EXE, DEMO1.DT1, DEMO2.DT2 and CASE.CAS). From the DOS prompt type "CORD". After a short period of disk activity, the CORD main menu should appear on the screen.

Select the CORD demo plot to be the current image by pressing "I" until "DEMO PLOT" is highlighted. Data for this plot are shown in Table 1.2 above. Display the demo plot by pressing "V". A somewhat warped version of Figure 1.2 should appear on the screen. The figure is distorted because the screen aspect ratio is still set at its default value of 1.0.

To determine what the screen aspect ratio should be, CORD requires one piece of information from the user. It must know the height to width ratio for a reference test pattern. CORD provides a "hard-wired" test pattern for this purpose. Press <ESC> to return to the main menu. Now, select the test pattern by pressing "I" until "TEST PATTERN" is highlighted, and then display it by

pressing "V". The user should see a rectangle surrounding an ellipse. When the screen aspect ratio is properly set, the rectangle appears square, and the ellipse becomes round. (See section 4.11 for more details.)

To find the current height to width ratio of the screen, first measure the height and width of the rectangle in the test pattern. This rectangle defines the extremes of the available graphics region. We suggest making these measurements by laying a piece of paper over the screen, marking the paper with the dimensions of the rectangle, and then measuring the distance between these marks. Measurements in millimetres are convenient, but the scale is irrelevant since only the ratio is required. Find this ratio by dividing the height of the rectangle by its width. Record this figure to four decimal places and keep it handy for future reference. Press <ESC> to return to the main menu.

To set the correct screen aspect ratio, press "A" to bring up the aspect ratio menu and then "S" to select the "Screen aspect ratio" option. A prompt for the observed height to width ratio appears. Type in the value calculated from the test pattern. CORD then displays the new screen aspect ratio. The disk drive becomes active at this point while CORD saves this value to a file called "CORD.ASP" (section 4.11). Press <ESC> twice to return to the aspect ratio menu and then to the main menu.

View the CORD demo plot again by selecting it with the "I" option and then view it by pressing "V". The plot should now be correctly displayed with circles that appear round, as in Figure 1.2.

CORD maintains a maximum radius length to accommodate data with arbitrary values of r. Note that the longest vector in the plot terminates just inside the outer circular boundary. This happens because the current maximum radius length equals the largest r in the data for the demo plot.

The user is free to change this value using the "Maximum radius length" option on the main menu. Select this option now by pressing "M". Try entering several different values for the maximum radius length. The user may enter any value greater than 0.0. View the demo plot after each modification. Notice values smaller than 22.8 result in some or all vector lines being pushed off-scale, consistent with the data for this plot (Table 1.2). Try a value smaller than 22.8 to see that CORD indicates off-scale vectors by terminating them with a large dot.

Enter "M" again at the "Enter the maximum radius length" prompt. Entering "M" (for "maximum") at this prompt resets the value so that the longest vector terminates at the extreme of the plottable region.

Return to viewing the demo plot and note the small circle at the centre of the screen. This inner circle serves to spread the vectors and their labels when their directions are closely aligned. CORD provides an option on the main menu for altering the size of this circle. Press <ESC> to exit to the main menu. Select the "Radius of inner circle" option by pressing "R". CORD displays the current radius and then prompts for a new one. The radius here is specified as a fraction of the radius of the outer circular boundary. Only

fractions in the range [0,0.5] are allowed. Enter the value 0.4, and view ("V" at the main menu) the demo plot again. Notice the effect of changing the radius to 40% of the outer radius. Press <ESC> to return to the main menu.

Finally, note the options to turn arrow heads on/off, a diagram border on/off, and compass markings on/off. These switches are toggled by pressing "H","B", or "C" respectively. Try changing these switches and viewing the demo plot after each modification to see its effect.

2.2. Working with data from pre-defined files

We next describe the process of plotting data from disk files and printing the result. Press "L" to activate the file menu, and "L" again to list the CORD files present in the current directory. The screen is now be divided by a dashed line which separates the menu in the top portion of the screen from the list of files in the bottom. This list is grouped according to file extension, where ".DT1" refers to type 1 data (as in Table 1.1), ".DT2" to type 2 data (as in Table 1.2), and ".CAS" to "cases" selected from a data set. Among the files in the .DT1 group should be a file called DEMO1.

Load the file DEMO1.DT1. To do this, press "1" to select the "Load type 1 data file (.DT1)" option. A prompt requests a filename while the file list remains present on the screen. Enter the name, "demo1". After some disk operation the file menu is displayed again. CORD has stored the data from this file in the computer's memory. Press <ESC> to return to the main menu.

CORD automatically selects the data set plot as the current image upon loading the data file. Press "V" to view the CORD plot of the current data set. A set of 200 vectors should appear on the screen. Since a diagram with so many vectors can be confusing, it is appropriate to select experiments for a more restrictive plot.

To select a list of cases from the data file, first press "L" twice to display a list of available case select files. Among the files in the .CAS group should be a file named "CASE", which contains a list of case numbers. When loaded, it causes only the vectors associated with these case numbers to be plotted. Load it by pressing "C" and then entering "case" at the prompt. Press <ESC> to return to the main menu.

View the plot again by pressing "V". Notice that the original profusion of vectors has thinned considerably. Also, the space within the outer circular boundary is not being used as effectively as it could be. This is because CORD is using a maximum radius originally selected for the entire data set. Force CORD to reselect an optimum value for current selected subset by choosing the "Maximum radius length" option from the main menu and entering "M" (for maximum) at the prompt. Now, view the image again to see the effect. As was the case with the demo plot, any value greater than 0.0 can be entered as the maximum radius length. For comparative use of CORD plots, it may be preferable to use a fixed radius on a series of plots, rather than the optimum for each.

To produce a hardcopy, press "P" to activate the printer menu. Select an appropriate printer mode from the list by its number, and accept 1.0 as the

default magnification value. CORD then prints the current image, here the plot of the data set. Typically, the printed image has a distortion similar to that encountered earlier on the screen. This is to be expected, since the printer aspect ratio must be reset from its default value of 1.0.

To set the correct printer aspect ratio, follow a procedure similar to that for the screen aspect ratio. Select the test pattern as the current image. Press "P" to activate the printer menu. Choose an appropriate printer mode, and enter 1.0 as the magnification value. When the printer is finished, measure the height and width of the rectangle on the page, and (as with the screen) calculate the observed height to width ratio.

To set the printer aspect ratio, press "A" ("Aspect Ratios") at the main menu and then "P" ("Printer aspect ratio"). Enter the calculated value at the prompt. CORD displays the new value, and the disk drive is active for a moment while CORD saves it to the "CORD.ASP" file. Press <ESC> to return to the main menu and then "P" to activate the printer menu. Select the same printer mode used to print the test pattern, and enter 1.0 as the magnification value. The printer should produce a corrected plot of the data set. Note that, in general, each printer mode has its own aspect ratio, which, however, is not altered by the magnification factor. For maximum resolution, printing always takes place from a (possibly distorted) figure drawn to the full height and width of the screen.

We also supply a type 2 data file. Press "L" twice to bring up the file menu and a list of CORD files in the active directory. The ".DT2" files include one called "DEMO2". Load this file by pressing "2" and entering "DEMO2" at the prompt. Repeat the CORD functions demonstrated with the "DEMO1" file. In particular, use the sample ".CAS" file to select a sublist of the data.

3. CREATING DATA FILES FOR USE WITH CORD

3.1. CORD file types

As suggested in the introduction, CORD uses two distinct types of data files which we designate types 1 and 2. A third file type is used to select subsets of the data provided by these data files. All CORD file types are stored as plain ASCII files. Most text editors (e.g. Q-Edit™) and word processors (e.g. WordPerfect™, WordStar™) can produce files of this format. The DOS utility EDLIN can also be used. To determine the exact procedure for creating such files, refer to the manual for your text editor or word processor.

3.2. Specifications of type 1 data files

Each row (or record) in a type 1 data file has three fields (called "case", "r" and "θ") which summarize results from an animal orientation experiment. The "case" field serves to identify each experiment. The "r" field indicates the strength of the tendency of animals to orient in the principle direction, which is specified by the angle "θ" measured in degrees clockwise from north.

The following points define the format of a type 1 data file (illustrated in Figure 3.1):

1) The first two lines are ignored by CORD. They may contain any text convenient to the user. They **MUST NOT CONTAIN DATA**, as they are be disregarded by CORD. Usually, the first line contains titles ("case", "r", "theta"), and the second line is blank. Alternatively, one line might be used as a file description (e.g. "Experiments in August, 1989").
2) The case field may contain only integer values.
3) The r and θ fields may hold real or integer values.
4) There must be at least one space between fields. There is no maximum spacing between fields, with the sole condition that all three fields must reside on one line.
5) Only one record (case, r, θ) should reside on any given line.
6) With the exception of the first two lines, there must be no blank lines in the file.
7) Records must appear in the order of their case numbers, with the smallest case number appearing first. Case numbers need not, however, be sequential; thus five records with case numbers 1,5,7,8,10 are acceptable.
8) The file name must have the DOS extension ".DT1".
9) The maximum number of lines (experiment summaries) is 2000. This value may be changed by any user who possesses a copy of Turbo Pascal (v5.0 or greater). The value appears as "maxCases" in the constants section near the top of the CORD.PAS file. The upper limit of the value is restricted only by the amount of available RAM.

These two lines / MUST NOT contain \ data

Case	r	theta
1	1.1	340
2	2.5	320
3	1.3	70
4	1.5	200
5	0.9	115

Figure 3.1 - Example of a type 1 data file with extension ".DT1".

3.3. Specifications of type 2 data files

As in type 1 files, each row in a type 2 file summarizes an animal orientation experiment. Type 2 data include four fields: "case", "r", "θ", and "λ". The first three have the significance discussed above, and λ indicates the fraction of animals that orient in the primary direction θ. The remaining fraction ($1-\lambda$) of animals orient in the opposite direction.

Specifications of type 2 files (illustrated in Figure 3.2) are similar to those for type 1, with the following additions and exceptions:

1) The λ field must contain a value in the range $0.5 \leq \lambda \leq 1.0$. (Actually, values $0 \leq \lambda \leq 1$ are acceptable; however, as discussed in section 1.1, if $0 \leq \lambda \leq 0.5$, then λ and θ are replaced internally by $1-\lambda$ and $\theta+180°$, respectively.)
2) This type of file must have a file name with the DOS extension ".DT2".

These two lines / MUST NOT contain \ data

Case	r	theta	lambda
1	16.1	340	0.55
2	22.2	320	0.77
3	16.9	70	0.60
4	5.7	150	0.80
5	20.3	235	0.65

Figure 3.2 - Example of a data type 2 file with extension ".DT2".

3.4. Specifications of CORD case select files

Case select files allow the user to select subsets of experimental data by requesting specific summaries by their case numbers. CORD case select files have only one data field per line. This data field, labelled "case", contains an integer which selects an experiment summary to be plotted.

The specifications of case select files (illustrated in Figure 3.3) are as follows:

1) As with the data file types, the first two lines should not contain data but may contain any desired text.
2) The case number field must contain an integer value.
3) Only one case number should reside on any given line.
4) The name of a case select file must have the DOS extension ".CAS".

These two lines / MUST NOT contain \ data

Case
1
2
3
9

Figure 3.3 - Example of a case select file with extension ".CAS".

4. USING CORD

4.1. CORD menu operation

CORD menus request input in one of two forms; a keystroke or the entry of a numeric value. The appropriate keystroke for each menu option is listed on the menu in double quotes followed on the right by a description of the option. Numeric input, when required, is typed in by the user. At prompts requesting numeric input, pressing <ENTER> without entering a value causes the current value to be maintained. If a value has not been previously set by the user, the default is accepted. With the exception of the main menu, any selected option can be exited by pressing the <ESC> key.

4.2. The CORD main menu

Figure 4.1 illustrates the CORD main menu. An option on the menu is selected by pressing the key indicated in quotes next to each menu option. Items displayed in inverse text indicate settings which the user may alter by selecting the accompanying option. The <ESC> key has no effect on the main menu.

4.3. Selecting the current image

Striking the "I" key at the main menu causes the selection of the active image to cycle through the three possibilities listed below the option text. The image name displayed in inverse text is recognized by CORD as the current image. The current image is the image that CORD uses when the view or print options are selected. The settings displayed on the main menu change to reflect the setting of the current image.

The three images available are as follows:

1) TEST PATTERN - An image for use as a reference when determining screen and printer aspect ratios.
2) DEMO PLOT - A CORD plot of the type 2 data in Table 1.2. It provides novice users with the opportunity to try some of the features of CORD without having to provide a data file. This image (shown in Figure 1.2) is used extensively in the interactive example in section 2.1.
3) DATA SET PLOT - A CORD plot of data from a selected data file or (if a case select file has been loaded) a subset of data from the file.

4.4. Viewing CORD plots

Press "V" at the main menu to display the current image. If the data set plot is the current image, the diagram plotted depends on the type (1 or 2) of the current data set. Additionally, if a case file has been loaded, only the cases selected by this file are plotted. If a case file has not been loaded, then all cases in the data set are used. The message "No data file selected" is displayed if no data have been loaded. The user should note that vector lines terminating in large dots are off-scale relative to the current maximum radius (refer to section 4.6).

```
                    CORD Main Menu

"I" - select Image
      TEST PATTERN  DEMO PLOT  DATA SET PLOT

"V" - View current image
"L" - Load data and case select files
      Current Data File: DEMO1.DT1
      Current Case File: CASE.CAS

"M" - Maximum radius length   22.8000
"R" - Radius of inner circle   0.0500
"H" - arrow Heads  ON
"B" - Border  OFF
"C" - Compass markings  ON
"A" - Aspect ratios
      screen :  0.7677
      printer:  1.2178 -> MODE #1

"P" - Print current image

"Q" - QUIT - Exit to DOS

                    Choice: _
```

Figure 4.1 - The CORD main menu.

Plots viewed with this option are subject to the current program settings. The demo plot and the data set plots are affected by the screen aspect ratio, maximum radius length, and inner circle radius, as well as switch settings for arrow heads, diagram border, and compass markings. For the test pattern, however, the only relevant setting is the current screen aspect ratio.

The user may return to the main menu after viewing the image by pressing any key.

4.5. The file menu

Press the "L" key to display the file menu. This provides control over the loading and listing of CORD files. Only files in the directory active when the CORD program was started are available. Options on this menu are selected by pressing the key enclosed in double quotes to the left of the option description.

If the user attempts to load a CORD file not present in the active directory, the message "File not found. Please try again." is displayed. If this situation arises, check that the file name was entered correctly. If this

was not the source of the problem, then exit from CORD and inspect the file. To exit the file menu, press <ESC>; to exit CORD press "Q" at the main menu.

4.5.1. Loading type 1 data files (.DT1)

Pressing "1" at the file menu causes the program to prompt for a file name. The DOS extension (".DT1") should not be included in the name entered here. Type 1 files must conform to the specifications outlined in section 3.2.

4.5.2. Loading type 2 data files (.DT2)

Pressing the "2" key at the file menu causes the program to prompt for a file name. As with the previous option, the DOS extension of the file name (".DT2") should not be included in the name. Type 2 files must conform to the specifications outlined in section 3.3.

4.5.3. Loading case select files (.CAS)

Pressing "C" at the file menu causes the program to prompt for a file name. Again, the DOS extension (".CAS") should not be included. Case select files must conform to the specifications outlined in section 3.4.

Loading a case select file limits the current plot to experiments with case numbers in that file. Reloading the current data file or loading a different data file resets the default of plotting all cases.

4.5.4. Listing available CORD files

Selection of the "L" option at the file menu causes the CORD files in the active directory to be listed. The files are grouped according to their DOS extension (i.e. ".DT1", ".DT2" and ".CAS"). This list of available files remains on the screen for reference while various file menu options are selected.

4.6. Changing the maximum radius length

The maximum radius represents the length corresponding to the longest possible vector in a CORD plot. Thus, the maximum radius controls the correspondence between the radius of the plottable region on the screen and the r values in a set of experimental data.

The maximum radius length is automatically set when a data file is loaded so that the longest vector line is just within the outer circular boundary. The user may opt to change this value by selecting the "M" option from the main menu. Any value greater than or equal to 0.0 may be entered. Notice, however, that values too large give an indistinguishable cluster at the centre of the plot, and values too small result in vectors being plotted off-scale. Such vectors terminate in large dots to indicate this condition.

Pressing the <ENTER> key without entering a value leaves the maximum radius unchanged. Entering "M" as the maximum radius automatically reselects

the maximum radius in the current data. Incidentally, the maximum radius is plotted as 85% of the radius of the circle surrounding a CORD diagram.

A maximum radius for the demo plot is maintained separately from the maximum radius for the data. The current maximum radius (displayed with the "M" option) depends on which image is currently active. A maximum radius does not apply to the test pattern; thus, no value is displayed when it is active.

4.7. Changing the radius of the inner circle

The centre of a CORD plot includes a circle that spreads apart the vectors and their accompanying labels. The user can vary the radius of this inner circle by selecting the "R" option from the main menu.

The radius of the inner circle is selected as a fraction of the radius of the outer circle that surrounds the plots. The allowable range of this fraction is [0,0.5]. Entering an unacceptable value causes the prompt to be repeated. As usual, pressing <ENTER> without specifying a value leaves the current radius unchanged.

4.8. Turning arrow heads on/off

Pressing "H" at the main menu toggles the status of the arrow heads switch. When this switch is on, arrow heads appear at the vector ends.

4.9. Turning the diagram border on/off

Pressing "B" toggles the status of the diagram border switch. When this switch is on, a square border is drawn around the diagram.

4.10. Turning the diagram compass markings on/off

Pressing "C" toggles the status of the compass markings switch. When this switch is on, compass markings are drawn on the diagram.

4.11. Screen and printer aspect ratios

In order to plot correct images (in which squares appear square and circles appear round) on any monitor or printer, corrections are required for distortions due to differing graphics standards and idiosyncrasies of particular hardware. CORD achieves this by using "aspect ratio" correction factors, one for the screen and one for each of the eight supported printer modes.

The aspect ratio menu is displayed when the user presses "A" at the main menu. As a part of this menu, CORD lists the current screen aspect ratio and the printer aspect ratio for each printer mode. The value for the current printer mode is shown in white, and the remaining printer values are displayed in gray. CORD automatically saves the screen and printer aspect ratios in a file, "CORD.ASP". This file is updated every time an aspect ratio is changed.

4.11.1. Setting the screen aspect ratio

The screen aspect ratio effects the video image as follows:

- An aspect ratio of 1.0 means that the entire vertical and horizontal resolution of the screen is used to plot graphics data.
- A ratio of less than 1.0 means that a fraction of the horizontal resolution equal to the value of the ratio is used.
- A ratio of greater than 1.0 means that a fraction of the vertical resolution equal to the reciprocal of the ratio is used.

Thus, when the screen aspect ratio is changed from 1.0, the screen image is always contracted, either horizontally or vertically.

Setting the aspect ratio for the screen involves making physical measurements. CORD provides a test pattern for this purpose. To set the screen aspect ratio, use the following procedure.

1) Select the test pattern to be the active image by pressing the "I" key until "TEST PATTERN" is highlighted.
2) Display the CORD test pattern by pressing "V" at the main menu.
3) Measure the height and width of the rectangular border of the test pattern. This can be done by marking the distances on a piece of paper and then measuring between the marks.
4) Calculate the observed screen aspect ratio by dividing the observed height by the observed width.
5) Press <ESC> to return to the main menu.
6) Press "A" to select the screen and printer aspect ratio option.
7) Press "S" to select the screen aspect ratio option.
8) Enter the newly calculated aspect ratio.
9) Press <ESC> twice to exit to the main menu.

CORD should now produce circular plots on the screen. If not, repeat the above procedure. If any monitor settings are changed, such as vertical or horizontal size, the screen aspect ratio factor may need resetting.

4.11.2. Setting the printer aspect ratio

The printer aspect ratio effects the printed image as follows:

- A ratio of 1.0 means that for every dot on the screen, one dot is printed on the page.
- A ratio less than 1.0 means that the number of dots printed vertically down the page is equal to the vertical resolution of the screen divided by the ratio.
- A ratio greater than 1.0 means that the number of dots printed horizontally across the page is equal to the horizontal resolution of the screen multiplied by the ratio.

Thus, when the printer aspect ratio is changed from 1.0, the image is always expanded horizontally or vertically. Note that this is opposite to the effect of the screen aspect ratio, which can only cause a contraction of the image.

The procedure for setting the printer aspect ratio is similar to that for the screen. The user should note that the screen aspect ratio is automatically set to 1.00 while an image is being printed. Thus, the user should not be alarmed at the distorted appearance of images on the screen while using the "P" option. The steps are as follows:

1) Select the test pattern to be the active image by pressing the "I" key until "TEST PATTERN" is highlighted.
2) Press "P" to bring up the printer menu.
3) Select the printer mode for which you wish to set the aspect ratio.
4) Select a magnification value of 1.0 at the magnification value prompt.
5) When printer has finished, measure the height and width of the outside border of the test pattern.
6) Calculate the observed printer aspect ratio by dividing the observed height by the observed width.
7) Press "A" to select the screen and printer aspect ratio option.
8) Press "P" to select the printer aspect ratio.
9) Enter the newly calculated aspect ratio.
10) Press <ESC> to exit to the main menu.

CORD should now produce circular plots on the printer. If not, repeat the above procedure. Bear in mind that a printer aspect ratio must be determined separately for each printer mode. It is, however, unaltered by the magnification value.

4.12. Printing CORD plots

CORD can produce high-quality reproductions of screen plots on Epson FX-80 and Hewlett Packard LaserJet Series II compatible printers. To print a CORD plot, bring up the printer menu by selecting the "P" option from the main menu. Then specify a printer mode and a printer magnification value. CORD prints the current image (i.e., the one indicated in inverse text on the main menu). As CORD prints an image, it is displayed full screen (screen aspect ratio=1.0), so that a distorted screen image while printing is normal. This use of the screen generates maximum resolution in the printed image.

4.12.1. Selecting a printer mode

The user must consider a number of factors when selecting a printer mode. With Epson compatible printers, higher resolution requires longer print times. For instance, the quad density mode is slower than the double density mode but has twice the resolution. With LaserJet Series II printers, the main consideration is the amount of on-board printer RAM. For example, the 300 DPI mode has twice the resolution of the 150 DPI mode, but requires twice the amount of printer RAM for the same image. LaserJet Series II printers abort images that require more than the available RAM.

A printer mode is selected by its number on the menu list. Pressing <ENTER> at the prompt leaves the current mode unchanged. The initial default selection is mode 1. Table 4.1 lists the available printer modes.

Table 4.1 - Printer modes available in CORD

1)	Epson FX-80	- Double Density Double Speed
2)	Epson FX-80	- Quad Density
3)	Epson FX-80	- Standard Density
4)	Epson FX-80	- Double Density
5)	HP LaserJet II	- 75 DPI
6)	HP LaserJet II	- 100 DPI
7)	HP LaserJet II	- 150 DPI
8)	HP LaserJet II	- 300 DPI

4.12.2. Selecting a printer magnification factor

The printer magnification factor causes an enlargement of the printed image in both height and width. Thus, the factor 1.0 leaves the image unchanged, and the factor 2.0 gives an image doubled in height and width. The printer magnification factor can take on any real value greater than 0. Pressing <ENTER> without entering a value leaves the current value unchanged. A magnification factor less than 1.0 can be used, but this always results in loss of resolution.

4.13. Exiting CORD

The user may exit the program by pressing "Q" while at the main menu. Exiting the program leaves the user at the DOS prompt.

REFERENCES

Kuhn, B.R., D.W.A. Whitfield, and T. Chumak. 1988. THE CUSTOM GRAPHICS PACKAGE: A Pascal programmer's graphics toolbox and data presentation system. Can. Tech. Rep. Fish. Aquat. Sci. 1659: xii + 150 p.

Schnute, J., and K. Groot. 1989. Analysis of bimodal orientation data. MS in preparation.

APPENDIX A - OBTAINING THE CORD SOFTWARE

To receive a copy of this software package, you must agree to, fill in, and sign (with two witnesses) the attached WAIVER AND USE AGREEMENT. We apologize for the formality of this agreement, but Canadian Federal Regulations require it. In addition, you must send one FORMATTED STANDARD 360KB FLOPPY and a self-addressed floppy-disk mailer. The diskette should be clearly labelled as follows:

CORD: CIRCULAR ORIENTATION DIAGRAM PACKAGE
(C) 1989 CANADIAN DEPT. OF FISHERIES AND OCEANS
COPY FOR (your name here)

We must have your signed waiver, a formatted diskette labelled as above, and a self-addressed floppy-disk mailer before we can process your request.

To receive a copy of this manual, send a brief note detailing your request and a self-addressed mail label. Send all requests to the second author:

Jon Schnute,
Pacific Biological Station,
Nanaimo, B.C. V9R 5K6,
CANADA

THE CIRCULAR ORIENTATION DIAGRAM PACKAGE SOFTWARE WAIVER AND USE AGREEMENT

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the Corporate Seal of (company)_____ was hereunto affixed this _____ day of _____, A.D. 19____.

The Corporate Seal of (company)_____ was hereunto affixed in the presence of:

(signature)_____
(name)_____

(witness signature)_____
(witness name)_____

(witness signature)_____
(witness name)_____

or, if individual:

IN WITNESS WHEREOF I have hereunto set my hand and seal this _____ day of _____, A.D. 19____.

Signed, sealed and Delivered
in the presence of

(signature)_____
(name)_____

(witness signature)_____
(witness name)_____

(witness signature)_____
(witness name)_____